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THE SEA LAMPREY IN THE GREAT LAKES

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SPREAD OF THE SEA LAMPREY THROUGH THE UPPER GREAT LAKES; ITS EFFECT ON THE LAKE TROUT FISHERY

The sea lamprey (Petromyzon marinus) is typically anadromous, that is, hatches and spends its early life in fresh water, migrates to the ocean where it grows to maturity, and returns to fresh water to spawn. It is during its life in the ocean that it is parasitic on fish. Sea lampreys have long been known in the streams of our Atlantic coast where they have been taken as far south as northern Florida.

In common with certain other anadromous species the sea lamprey has adjusted itself in some areas to spending its entire life cycle in fresh water. It is native, for example in Lake Ontario and some lakes of northern New York.

Prior to the construction of the Welland Canal in 1829, Niagara Falls stood as a barrier to the spread of the sea lamprey from Lake Ontario to the other Great Lakes. Even after the completion of the canal, the lamprey seems to have been slow to take advantage of the route, for the first specimen to be taken above the falls was captured in 1921, nearly a century later, in Lake Erie off Merlin, Ontario. It is possible, of course, that sea lampreys straggled through the canal repeatedly but were not seen or captured. The first known spawning population of the sea lamprey was discovered in 1932 in the Huron River, a tributary of Lake Erie.

The sea lamprey has never been able to establish itself in great numbers in Lake Erie, but once it reached Lake Huron its spread and increase in abundance were rapid. Well before the end of the 1930's Lake Huron fishermen began to complain of the increasing frequency of scarred lake trout in their catches and the deterioration in the quality of lake trout fishing. They expressed a grave fear that this parasite might destroy completely the fishery for the species.

That this fear was well grounded was borne out by subsequent experience. The speed and the completeness of the collapse of the lake trout fishery in Lake Huron is demonstrated by the following record of the catch in United States waters from 1935 through 1948:

Year	Pounds	Year	Pounds
1935	1,743,000	1942	728,000
1936	1,400,000	1943	459,000
1937	1,340,000	1944	363,000
1938	1,270,000	1945	173,000
1939	1,372,000	1946	38,000
1940	940,000	1947	12,000
1941	892,000	1948	4,000

The tentative figure for 1949 is only 912 pounds. The production figure for every year after 1939 set a new record low.

The first sea lamprey known to be captured in Lake Michigan was taken off Milwaukee in 1936. The rapid increase in abundance of the sea lamprey and the decline of the lake trout got underway later in Lake Michigan than in Lake Huron but aside from this difference of timing the trends have been much the same. How similar the course of the decline of the lake trout fishery in the two lakes has been is evident from the comparisons of the following record of production in Lake Michigan with that given earlier for the same years in Lake Huron.

Year	Pounds	Year	Pounds
1935	4,873,000	1942	6,484,000
1936	4,763,000	1943	6,860,000
1937	4,988,000	1944	6,498,000
1938	4,906,000	1945	5,437,000
1939	5,660,000	1946	3,974,000
1940	6,266,000	1947	2,425,000
1941	6,784,000	1948	1,196,000

Complete statistics for 1949 are not yet available, but the tentative estimate of 343,000 pounds should not be greatly in error. In Lake Michigan the series of record-low years began with 1947.

The actual loss of cash income to the commercial fishermen of Lakes Huron and Michigan resulting from the decreases in the take of lake trout amounts to approximately 3 million dollars. At a 4-percent interest rate this figure represents the annual return from a capital investment of 75 million dollars. When one considers how greatly the decrease of income to wholesalers and retailers of fish, to transportation companies, to manufacturers of fishing equipment and supplies,.....adds to the above value and remembers also that no estimate is included for species other than lake trout that have been harmed by the sea lamprey, the real gravity of the economic losses and the urgent need of sparing no effort to bring the parasite under control become even more obvious.

The sea lamprey was first reported from Lake Superior in 1945. Although specimens have been taken as far west as Minnesota, and spawning runs have been discovered as far west as Marquette, Michigan, lampreys have become plentiful only in the extreme eastern end. Any effects on the lake trout fishery, therefore, have been only local. Correspondingly, the production of lake trout in Lake Superior has held up as the following statistics for United States waters prove:

Year	Pounds	Year	Pounds
1935	3,476,000	1942	2,959,000
1936	3,234,000	1943	3,053,000
1937	3,085,000	1944	3,740,000
1938	3,167,000	1945	3,369,000
1939	2,744,000	1946	3,444,000
1940	2,677,000	1947	2,964,000
1941	2,854,000	1948	2,954,000

A fair estimate of 1949 production is 2,950,000 pounds.

We should not be too ready to take comfort from these production figures for Lake Superior, first, because records prove that the catch per net is declining and the yeild has been maintained in recent years only by greatly increased fishing pressure, and second, because experiences in Lake Huron and especially in Lake Michigan prove that complete collapse of a fishery can take place in only a few years.

In both Lake Huron and Lake Michigan the attacks by sea lampreys on other species increased as the abundance of lake trout fell. Although the injury to stocks so far has not been as great for other fish as for lake trout the damage to some varieties, particularly whitefish, suckers, and walleyes obviously is heavy and is increasing to an alarming extent in some waters. Seemingly all commercial species are subject to some lamprey depredations.

LIFE HISTORY OF THE SEA LAMPREY

Knowledge of the enemy is essential to the waging of a successful war; hence, information on the natural history of the sea lamprey is vital if we are to ascertain the vulnerable points in its life cycle. During the past several years researches sponsored by the State of Michigan and more recently by the Fish and Wildlife Service have added greatly to our information on this parasite. The following account is based largely on these investigations. For purposes of description the life cycle may be divided into two periods--stream life and lake life.

Mature sea lampreys enter the streams tributary to the Great Lakes for the purpose of spawning in late spring and early summer. This spawning migration extends over as many as 12 weeks. Temperature is a major controlling factor over these upstream movements. Heavy runs do not begin until the stream temperature reaches 50°F. If the temperature drops below that point, the run slackens off. There is evidence that lampreys are unable to spawn in streams that are too cold. They may enter them, but they later return to the lake.

For successful nest building the sea lamprey requires a bottom of coarse gravel and rubble in an area with a moderately strong current. Seizing stones with their sucker-like mouths, the sea lampreys build crescent-shaped nests. If the grounds are extensive in relation to the size of the spawning population, these nests usually are well spaced within the stream. If the grounds are congested, the nests are closely grouped and on occasion portions of the spawning areas are reworked by late arrivals.

When the eggs are extruded by the female and fertilized by the male, they are carried by the current into the gravel of the nests where they develop and hatch in 10 to 12 days according to temperature conditions. A single female may deposit as many as 107,000 eggs; the average number is about 61,500.

The sea lamprey spawns only once. All adults die soon after they complete spawning.

When the recently hatched larvae emerge from the nest, they drift downstream until they reach mud and silt flats. Here they dive for the bottom where each establishes itself in its individual burrow. The food, which is sucked in from the water passing the mouth of the burrow, consists largely of microscopic organisms that live in the surface film of the stream bottom. During the stream life the young lampreys are completely harmless.

According to our past evidence, the length of the larval life is about four years. During the final season in the stream the larvae begin to transform into the adult parasitic stage. Once the transformation is completed they emerge from the mud flats and drift lakeward.

The newly transformed larvae mostly range from 3.7 to 7.2 inches long and average 5.7 inches. The downstream movement always occurs at a time of rising water levels. Some of the young lampreys leave the streams in the late fall and a few migrate at various times during the winter, but the major downstream movement occurs at the time of breakup in the spring. When the young sea lampreys reach the lake they are ready to begin their parasitic existence.

During the parasitic phase of its life, the sea lamprey feeds on the blood and body juices of fish. It attaches itself to its victim by means of its sucker-like mouth and with its sharp teeth rasps a hole in the body. Lampreys kept in aquaria will remain attached to fish as long as three weeks provided the victim does not die. These same aquarium experiments proved that delicate species such as the brook trout are killed quickly but that more hardy fish as bullheads may survive attacks by several lampreys over a period of weeks.

Details on the life of the sea lamprey in the lake are scanty. Measurements of a considerable number of specimens indicate that the average time in the lake is about 1 1/2 years. There is some evidence also that the newly transformed sea lampreys migrate first to deep water where they attack lake trout, chubs, and other deep-water species. As the lampreys grow larger, they move shoreward and in the fall are to be found in relatively shallow water. It is at this time that attacks on whitefish, suckers, and other shallow-water fish reach their maximum.

Toward the end of winter and in early spring the sea lampreys begin to congregate in estuaries off the mouths of streams. During this waiting period preceding the spawning migration tremendous internal changes occur. The sex glands expand enormously and the digestive tract and other organs shrink. As a result of these changes the lamprey becomes incapable of feeding. The process of deterioration extends even to the musculature and skin. At the time of this general breakdown the lamprey is subject to extensive attacks by fungus.

PROGRAM FOR THE CONTROL OF THE SEA LAMPREY

According to the present state of our knowledge the most vulnerable period in the sea lamprey's life cycle occurs in the stream. Attacks on lampreys in the streams have been organized along three lines: prevention of spawning through the blocking of the stream and/or the capture and destruction of lampreys enroute to the spawning grounds; the destruction of larval lampreys before they emerge from the mud and silt flats; the destruction of the newly transformed migrants enroute to the lake. Of the three approaches, the first and third appear to offer the greatest promise. It is planned nevertheless to develop and test procedures along all lines. Nothing that has even an outside chance of yielding positive results will be ignored.

Prevention of spawning.--Tests are in progress or planned on a variety of weirs, traps, barrier dams, and sonic and electrical devices as a means of capturing or destroying spawning run sea lampreys or of preventing their movement upstream. In many streams this type of operation is handicapped severely by the necessity for avoiding injury to runs of such valuable food and game fish as suckers, northern pike, walleyes, and rainbow trout. This limitation makes it impossible, for example, to apply electrical charges that might prove lethal to lampreys or to bar passage upstream unless equipment can be developed that will block or kill the lamprey without blocking or greatly injuring fish. Similarly, weirs need to be equipped with traps so that fish can be passed up- or downstream while the lampreys are removed and destroyed. Barrier dams need similar traps unless they can be so constructed that they block the lampreys but are still low enough to be jumped by fish.

Devices that prevent the spawning of sea lampreys offer a positive method of attack but they have one great drawback--the tremendous cost of installation and operation in the many scores of streams that contain lamprey runs. The installation of weirs in small streams is not extremely expensive, but the larger weirs cost many thousands of dollars. Furthermore, these structures require regular and frequent attention and service if they are to be operated efficiently. A second difficulty with control based on the blocking or destruction of spawning-run sea lampreys lies in the circumstance that the benefits from these activities are long deferred. Since the larval life is approximately 4 years long and the length of the parasitic phase averages approximately 18 months, results from the blocking of runs cannot become apparent until more than five years have elapsed.

Destruction of larval sea lampreys.--The destruction of the larval lampreys offers the advantage that as many as four generations of young can be eliminated at one time and results can accordingly be expected in less than two years. The practical difficulties, however, are enormous. In most waters the larval beds are widely scattered throughout the stream. Some of the larger beds can be attacked, but the lampreys settle down in such small patches of silt (as those commonly to be seen on the downstream side of deadheads) that to locate and treat all of them is not feasible. For the very reason of this wide scattering the mechanical destruction of larval lampreys in silt beds does not seem practicable. Killing by electrical current has been considered but the results with equipment tested to date have not been promising. Apparently the conductivity of the bottom muds is too low in comparison with that of the stream water. The chemical treatment of larval beds offers some promise if we can solve the problem of poisoning the lampreys without making the stream water so toxic as to be lethal to fish.

Thought has been given also to the possibility of introducing animals that might prey on larval sea lampreys. In this connection the American eel gives some promise. Tests conducted in aquaria have demonstrated that eels will attack and destroy larvae. Whether similar results can be obtained under natural conditions remains to be determined. It is important also to make certain that any eels which might be introduced will not prove harmful to native fish.

Destruction of newly transformed sea lampreys.--The downstream migration of newly transformed larvae in the winter constitutes a period in the life cycle of the lamprey which offers even greater possibilities for destruction than the time of the upstream spawning migration. At this time of year the movements of fish are at a minimum. Consequently, equipment that kills any organisms passing along the stream inflicts only negligible damage on any animals other than lampreys.

Experiments have demonstrated that downstream migrants can be taken readily by means of a dam and inclined-screen trap, but this equipment is expensive to construct and requires regular attention. Furthermore, the topography of many streams does not lend itself to this type of structure. Far more promising are electrical installations that send a current through the stream sufficiently strong to kill the lampreys as they drift by. Attention is being concentrated on the development of apparatus that will give the greatest effectiveness at minimum cost. These devices must be so constructed as to be safe and to need only occasional inspection and service.

THE OUTLOOK FOR CONTROL

Biology, engineering, and economics--all of these must enter into our consideration when we speculate as to the possibility of developing a program for the effective control of the sea lamprey in the upper Great Lakes. The presently available information on the life cycle of the sea lamprey is sound and sufficiently extensive to serve as a basis for the initiation of control procedures. Certain aspects of the predator's natural history need to be explored further in order that we may judge better the most vulnerable points in its career. Only through more detailed

knowledge is the maximum efficiency to be obtained.

Economic considerations dictate that no effort be spared to accomplish the greatest destruction of sea lampreys at the least cost. If cost were no object, control might easily prove to be relatively simple. However, a control program that could be maintained at an annual figure approximating or exceeding the potential value of the fisheries could not be termed sound. Major effort is to be directed, therefore, toward the development of more and more destructive devices that call for less and less expense in installation and maintenance. The success or failure of attempts to control the sea lamprey well may be determined by the success or failure in the development of procedures, the cost of which can be economically justified.

There can be little doubt that the most effective control of the lamprey will be accomplished by a variety of procedures, each adapted to serve best under special local conditions.

Control of the sea lamprey will not be accomplished either in a short time or easily or cheaply. Furthermore, the control measures will need to be established on a continuing basis. The prospects for the eradication of this predator are so meager that they should not enter into our consideration in setting up a control program. We cannot hope for an immediate solution of the sea lamprey problem and a rapid return of the fisheries to their former productivity.

Figure 1.--Portrait of a sea lamprey taken from Lake Huron.

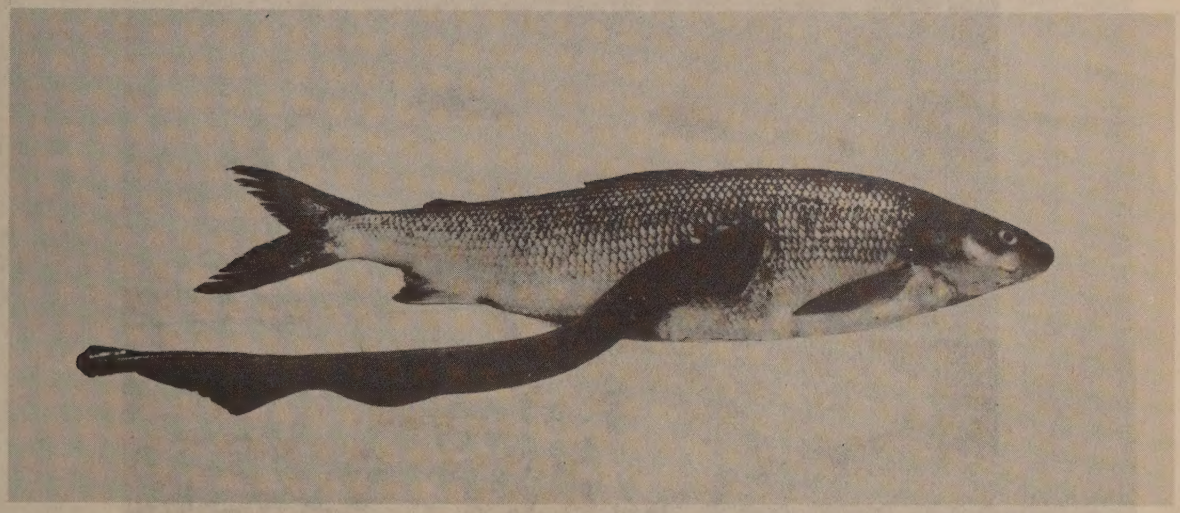

Figure 2.--Whitefish with sea lamprey attached as taken from a commercial fisherman's nets in Hammond Bay of Lake Huron.

Figure 3.--Sea lamprey weir in the Ocqueoc River, a tributary of northern Lake Huron. The cost of constructing this weir was $13,000; annual expenses for maintenance and operation amount to about $4,000.

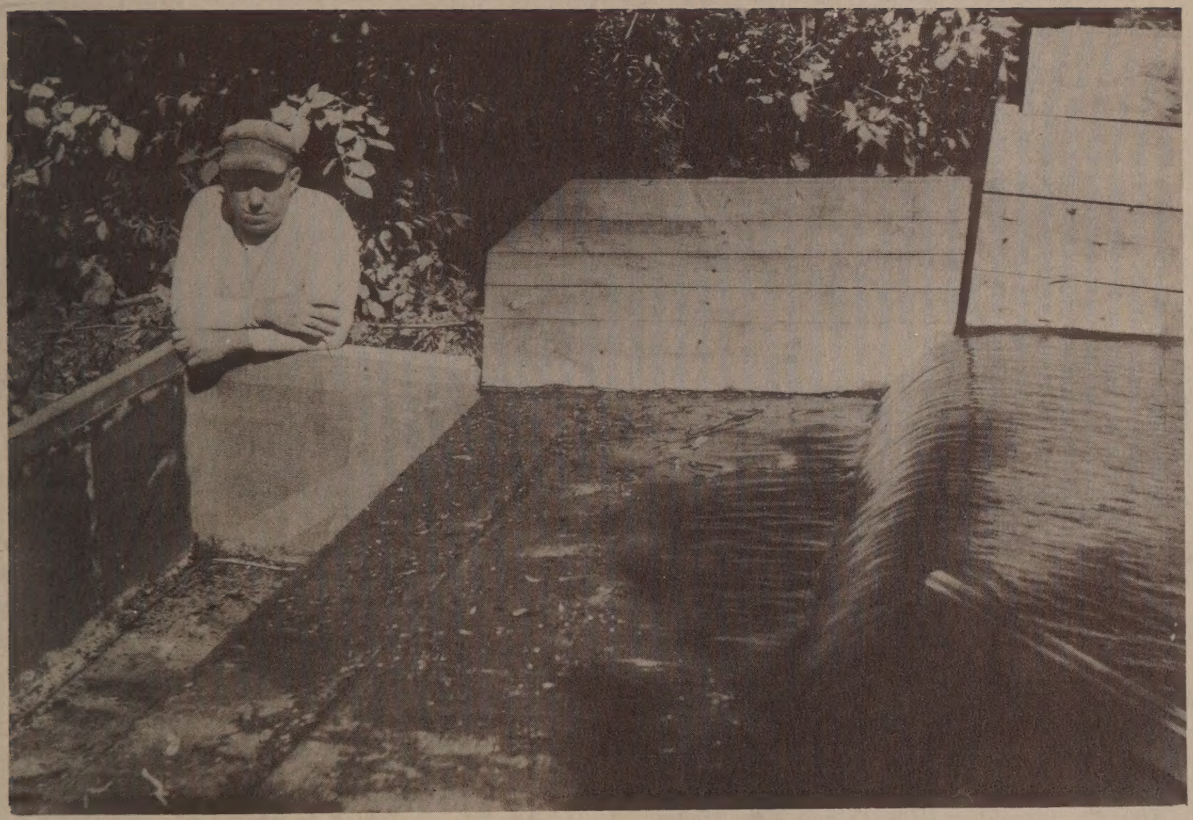

Figure 4.--Inclined-screen trap at a dam in the Carp Lake River, a tributary of the Straits of Mackinaw. This device proved effective in trapping the downstream runs of young, recently-transformed sea lampreys. The cost of constructing the dam and trap was $3,200; maintenance and operation costs are about $3,000 annually.

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